DSN Test and Training System

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Key characteristics of the Deep Space Network Test and Training System are presented. Completion of Mark III-75 system implementation is reported. Plans are summarized for upgrading the system to a Mark III-77 configuration to support Deep Space Network preparations for the Mariner Jupiter/Saturn 1977 and Pioneer Venus 1978 missions. A general description of the Deep Space Station, Ground Communications Facility, and Network Operations Control Center functions that comprise the Deep Space Network Test and Training System is also presented.

I. Introduction

A. Key Characteristics

The DSN Test and Training System is a multiple-mission system which provides capabilities to prepare the DSN for mission support. The key characteristics of the system are listed below:

(1) Supports calibrations, readiness verification, and fault isolation by providing composite signals for input to other DSN systems.

(2) Supports DSN operational verification tests by providing simulated telemetry, command, and radio metric data patterns.

(3) Supports performance testing of DSN systems, Deep Space Station (DSS) subsystems, and Network Control subsystems by providing closed-loop validation.

(4) Supports mission simulations by converting high-speed and wideband blocks of simulated telemetry data into serial streams modulated onto subcarriers and carriers; and by providing Command System operation with dummy load.

(5) Operates without interfering with normal operation of other DSN systems.

B. Mark III-75 System Implementation

Reference 1 describes the Mark III-75 configuration of the DSN Test and Training System, including incremental upgrade requirements for Viking Mars test and training support. The planned upgrade was completed in early 1975, as scheduled. The upgrade included implementation of a new software program for the Simulation Conversion Assembly (SCA) at all Deep Space Stations and new equipment to provide three-spacecraft telemetry simulation in the 64-m antenna subnet. The upgrade also

provided Network Operations Control Center capability to exercise remote control of the SCA.

C. Mark III-77 System Requirements

Further upgrading of the DSN Test and Training System to a Mark III-77 configuration (Fig. 1) is planned to meet requirements for support of network preparations for the Mariner Jupiter/Saturn 1977 (MJS'77) mission and the Pioneer Venus 1978 (PV'78) mission. The preparations for these missions include extensive implementation of new minicomputers to replace the existing XDS-920 processors in the DSS Telemetry, Command, and Tracking Subsystems.

The Mark III-77 configuration will include the following modifications and additions to the present system:

(1) Modification of the DSS Simulation Conversion Assembly to provide capability for short-constraint-length convolutional coding of simulated MJS'77 telemetry data and long-constraint-length convolutional coding of simulated PV'78 telemetry data.

(2) Upgrade of program software for the XDS-910 processor, associated with the SCA, to provide generation of MJS'77 and PV'78 frame-synchronized telemetry test data and control of new SCA equipment.

(3) Configuring of the DSS Communications Monitor and Formatter backup minicomputer to provide the System Performance Test Assembly functions of on-site closed-loop performance testing and validation of the Tracking, Telemetry, Command, and Monitor and Control Systems.

(4) Implementation of the Network Control Test and Training Subsystem in the Network Operations Control Center.

(5) Implementation of the DSN Test and Training System Control Console in the Network Operations Control Center.

Implementation of items (1), (2), and (3) is to begin in early 1976 and is to be completed at all Deep Space Stations by the end of 1977. The station-by-station schedule is such that all DSS Test and Training Subsystem capabilities will be available to support testing of the new data processing subsystems which are to be implemented at each station.

Items (5) and (6) are scheduled for completion in the first half of 1976 as part of the Block III implementation of the Network Control System project (Ref. 2).

II. Deep Space Station Functions

A. DSS Test and Training Subsystem

The functions of the DSS Test and Training Subsystem and the related interfaces are shown in Fig. 2.

1. Telemetry Simulation and Conversion. The telemetry simulation and conversion functions are performed by the Simulation Conversion Assembly, which is diagrammed in detail in Fig. 3. The digital and analog capabilities of the SCA are itemized in Tables 1 and 2, respectively.

2. System Performance Test Functions. The system performance test functions are performed by the System Performance Test Assembly (SPTA), which is diagrammed in detail in Fig. 4.

B. Receiver–Exciter Subsystem

The Receiver–Exciter Subsystem provides the following test and training functions:

(1) Generation of simulated S-band and X-band downlink carriers.

(2) Modulation of telemetry subcarriers from the SCA onto simulated carriers.

(3) Variable control of simulated downlink carrier frequency to permit simulation of doppler shifts.

(4) Provision of a transmitter dummy load for Command System test operations.

C. Antenna Microwave Subsystem

The Antenna Microwave Subsystem provides the following test and training functions:

(1) Variable attenuation of simulated downlink carrier signal level under control of the Simulation Conversion Assembly.

(2) Routing of simulated downlink carriers to masers and/or receivers.

(3) Mixing of simulated S-band downlink carriers.

D. Frequency and Timing Subsystem

The Frequency and Timing Subsystem provides the following support functions to the DSS Test and Training Subsystem:

(1) Reference frequencies inputted to the SCA.

(2) Time code and reference frequencies inputted to the SPTA.

(3) Generation and distribution of a simulated time signal which can be substituted for the true GMT

input to the various DSS subsystems. This capability is provided for realistic mission simulations in support of flight project testing and training activities.

III. Ground Communications Facility Functions

The DSN Test and Training System utilizes the Ground Communications Facility Subsystems for communicating data and information between the Network Operations Control Center (NOCC) or any Mission Operations Center (MOC) and the Deep Space Stations.

A. High-Speed Data Subsystem

The High-Speed Data Subsystem provides the following:

(1) Transmission of text messages, control messages, low-to-medium-rate simulated telemetry data, and simulated command data to any DSS from the Network Operations Control Center or from any Mission Operations Center.

(2) On-site loop-back of test data for systems performance testing and readiness verifications in the DSS.

B. Wideband Data Subsystem

The Wideband Data Subsystem provides the following:

(1) Transmission of simulated high-rate telemetry data to the 64-m subnet, the Compatibility Test Area in Pasadena, California, and STDN MIL-71 at Merritt Island, Florida, from the NOCC or from any MOC having wideband capability.

(2) On-site loop-back of test data for telemetry system performance testing and readiness verification in those stations which have wideband capability.

C. Voice Subsystem

The Voice Subsystem provides operator-to-operator communication of information for purposes of test coordination and monitoring of the DSN Test and Training System status.

IV. Network Operations Control Center Functions

A. Network Control Test and Training Subsystem

Planned functions and interfaces of the Network Control Test and Training Subsystem are shown in Fig. 5. Subsystem data flow details are further diagrammed in Fig. 6.

1. Present Capabilities. Test and training capabilities presently operational in the Network Operations Control Center are as follows:

(1) Selection and output of stored data blocks from the Block I Network Command Subsystem (XDS Sigma-5) to the DSS for system readiness verification.

(2) Off-line generation of recordings of high-speed data blocks for testing of the Block II real-time monitors in the Network Control Tracking, Telemetry, Command, and Monitor Subsystems.

(3) Selection and output of prepared Simulation Conversion Assembly text and control messages to the stations from the Block I XDS Sigma-5. This capability provides remote configuration and control of the Simulation Conversion Assembly for support of DSN Operational Verification Tests conducted by the Viking and Helios Network Operations Project engineers.

2. Future Capabilities. Test and training functions (Fig. 6) to be implemented in the Network Operations Control Center in 1976 are as follows:

(1) Real-time generation of data patterns for testing of the Network Control Tracking, Telemetry, Command, Monitor, Support, and Display Subsystems.

(2) Real-time generation of Simulation Conversion Assembly text and control messages, simulated telemetry data patterns, and simulated project commands for transmission to the Deep Space Stations.

B. DSN Test and Training System Control Console

A DSN Test and Training System Control Console (see Fig. 6) is scheduled for 1976 implementation in the Network Data Processing Area. The console will provide keyboards, a card reader, a magnetic tape unit, volatile displays, and a character printer, so that operation of the Test and Training System will be separate from the operations of the other DSN Systems.

References

1. Thorman, H. C., "DSN Test and Training System," in *The Deep Space Network Progress Report 42-20*, pp. 5–12, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1974.

2. Friesema, S. E., et al., "Network Control System Project Block III Software," in *The Deep Space Network Progress Report 42-28*, pp. 122–126, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1975.

Table 1. DSS simulation conversion assembly digital channel requirements

Capability	SCA-I DSS 11, 12, 44, 62, MIL 71	SCA-II DSS 14, 42/43, 61/63, CTA 21
Maximum number of simultaneous data streams	2 channels	Viking prime mission, 6 channels; Viking extended mission, 4 channels; other missions, 3 channels
Bi-orthogonal (32, 6) comma-free block coding	Viking, 2 channels; other missions, none	Viking, 3 channels; other missions, none
Short constraint length convolutional coding ($k = 7, r = 1/2$ or $1/3$)[a]	Rate = 1/2, 2 channels;[a] rate = 1/3, 1 channel[a]	Rate = 1/2, 3 channels;[a] rate = 1/3, 2 channels[a]
Long constraint length convolutional coding ($k = 32, r = 1/2$)	Helios, 1 channel; Pioneer 10/11, 1 channel; Pioneer Venus, 2 channels[a]	Helios, 1 channel; Pioneer 10/11, 1 channel; Pioneer Venus, 3 channels[a]
Variable rate control	1 bit/s to 250 ksps on each of 2 channels	1 bit/s to 250 ksps on each of 3 channels
Selection of discrete rates	8⅓, 33⅓ bits/s on each of 2 channels (uncoded)	8⅓, 33⅓ bits/s on each of 3 channels (uncoded)

[a]New requirements to be implemented in DSN Mark III-77 Test and Training System.

Table 2. DSS simulation conversion assembly analog signal capabilities

Capability	SCA-I DSS 11, 12, 44, 62, MIL 71	SCA-II DSS 14, 42/43, 61/63, CTA 21
Data and subcarrier signal conditioning	Biphase modulation, 2 subcarriers	Biphase modulation: Viking prime mission, 6 subcarriers; Viking extended mission, 4 subcarriers; other missions, 3 subcarriers
Subcarrier frequency generation	1 Hz to 10 MHz range	1 Hz to 10 MHz range
Modulation-index angle control	Controllable from 10 to 80 deg on each subcarrier	Controllable from 10 to 80 deg on each subcarrier
Subcarrier mixing and downlink carrier modulation	Single or dual subcarriers onto each of 2 S-band carriers	Single or dual subcarriers onto each of 3 S-band or X-band carriers
Downlink carrier signal level	Attenuation of 0 to 40 dB at output of each test transmitter	Attenuation of 0 to 40 dB at output of each test transmitter

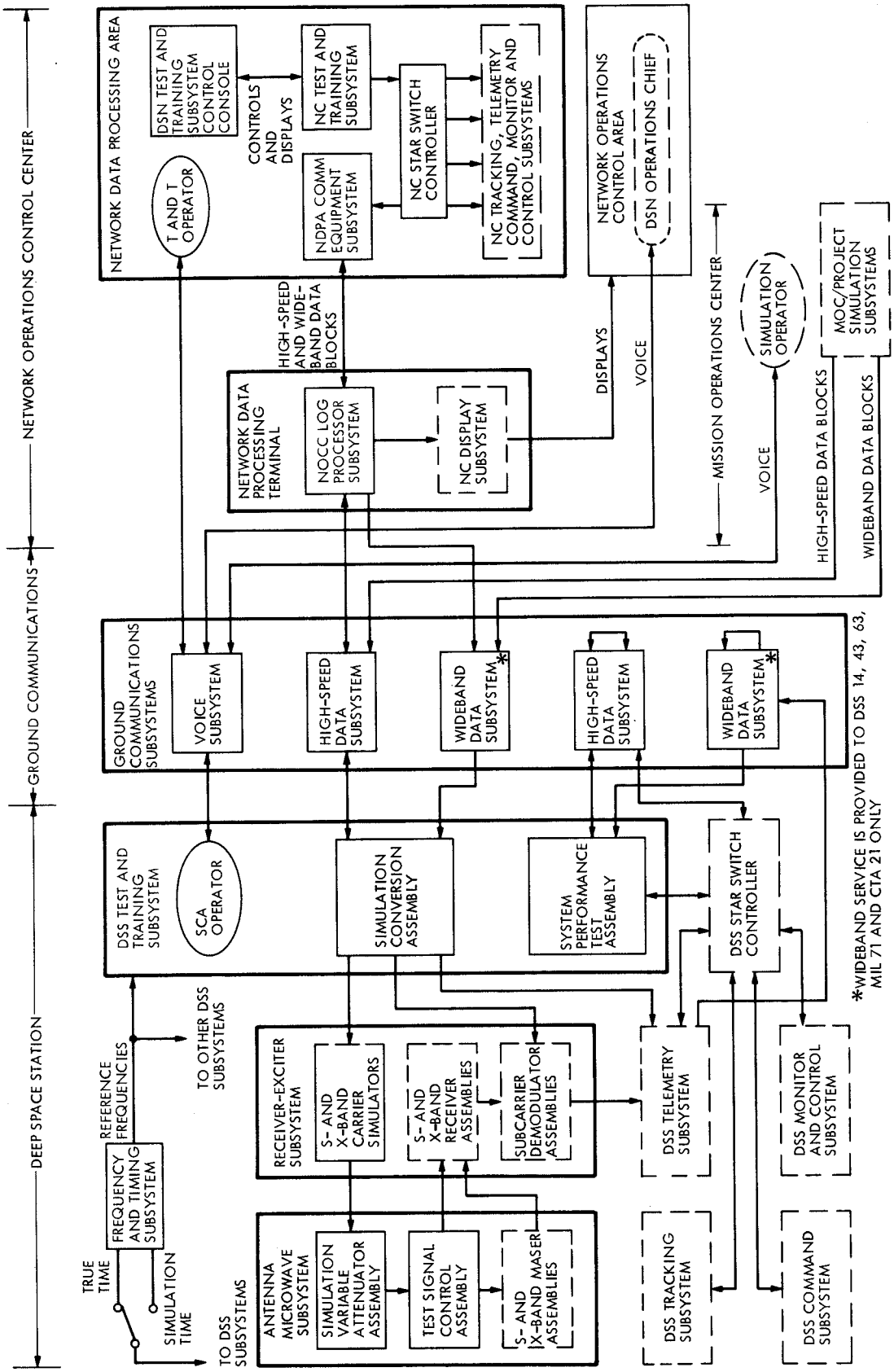

Fig. 1. DSN Mark III-77 Test and Training System block diagram

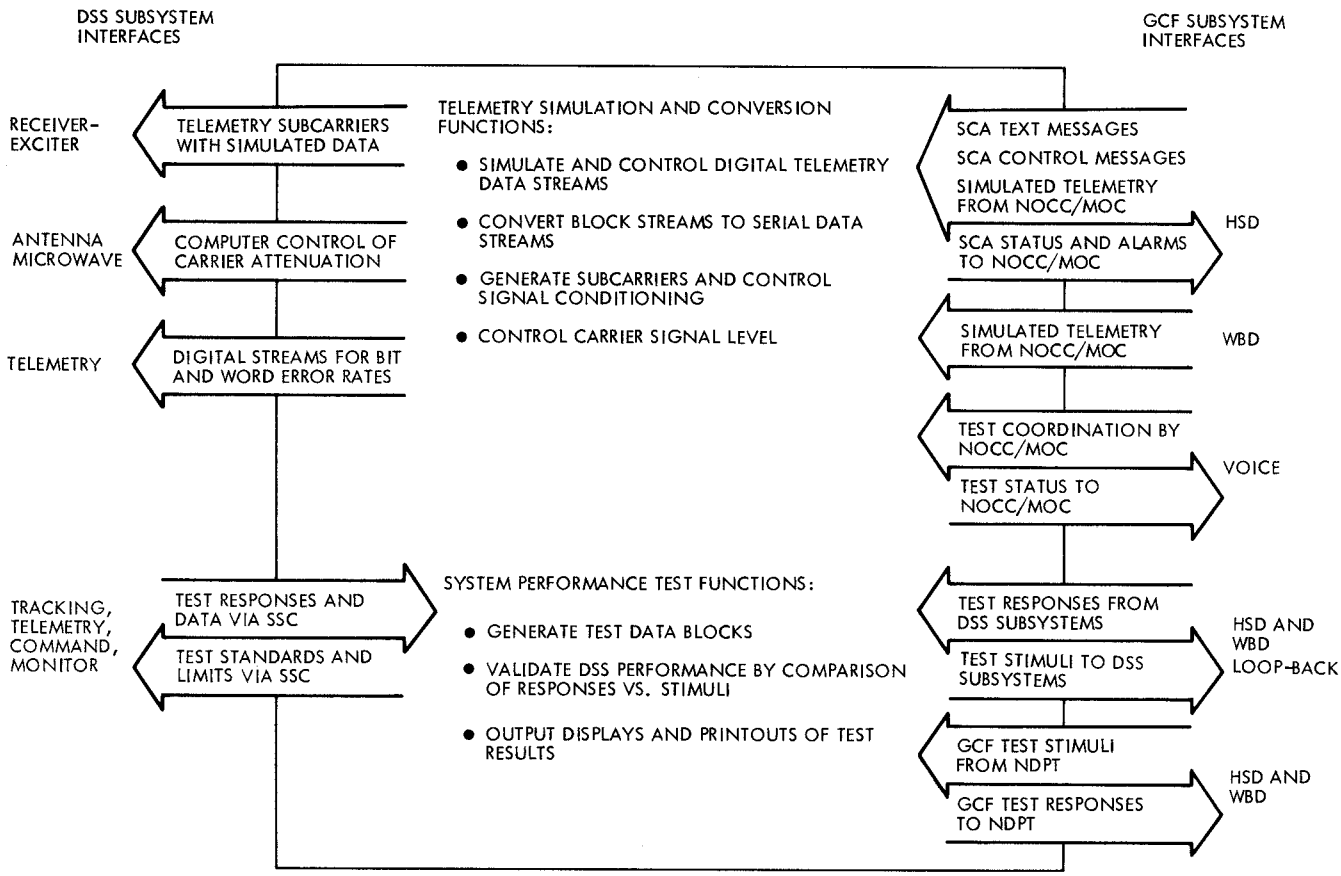

Fig. 2. DSS Test and Training Subsystem functions and interfaces

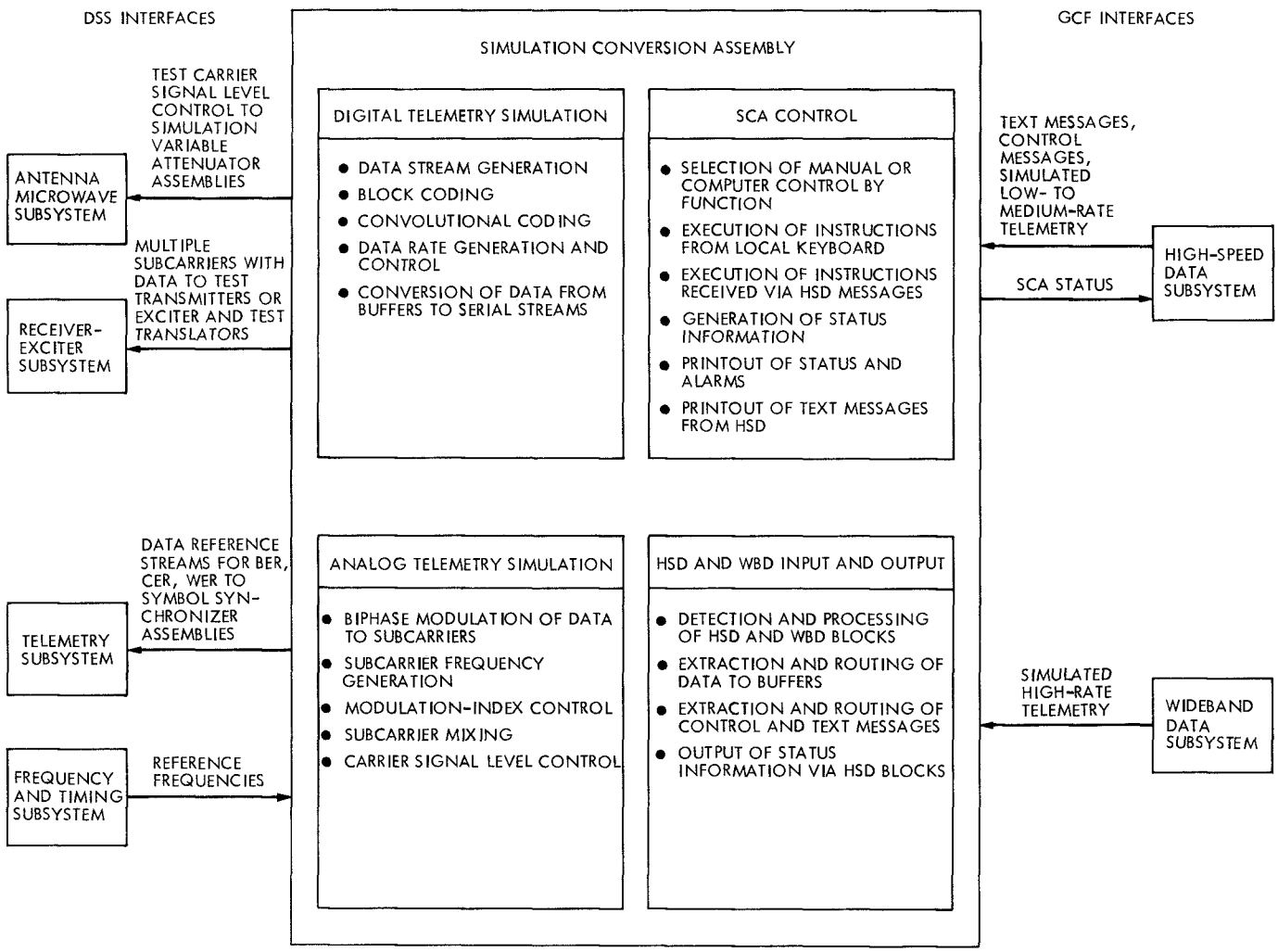

Fig. 3. Simulation conversion assembly functions and data flow

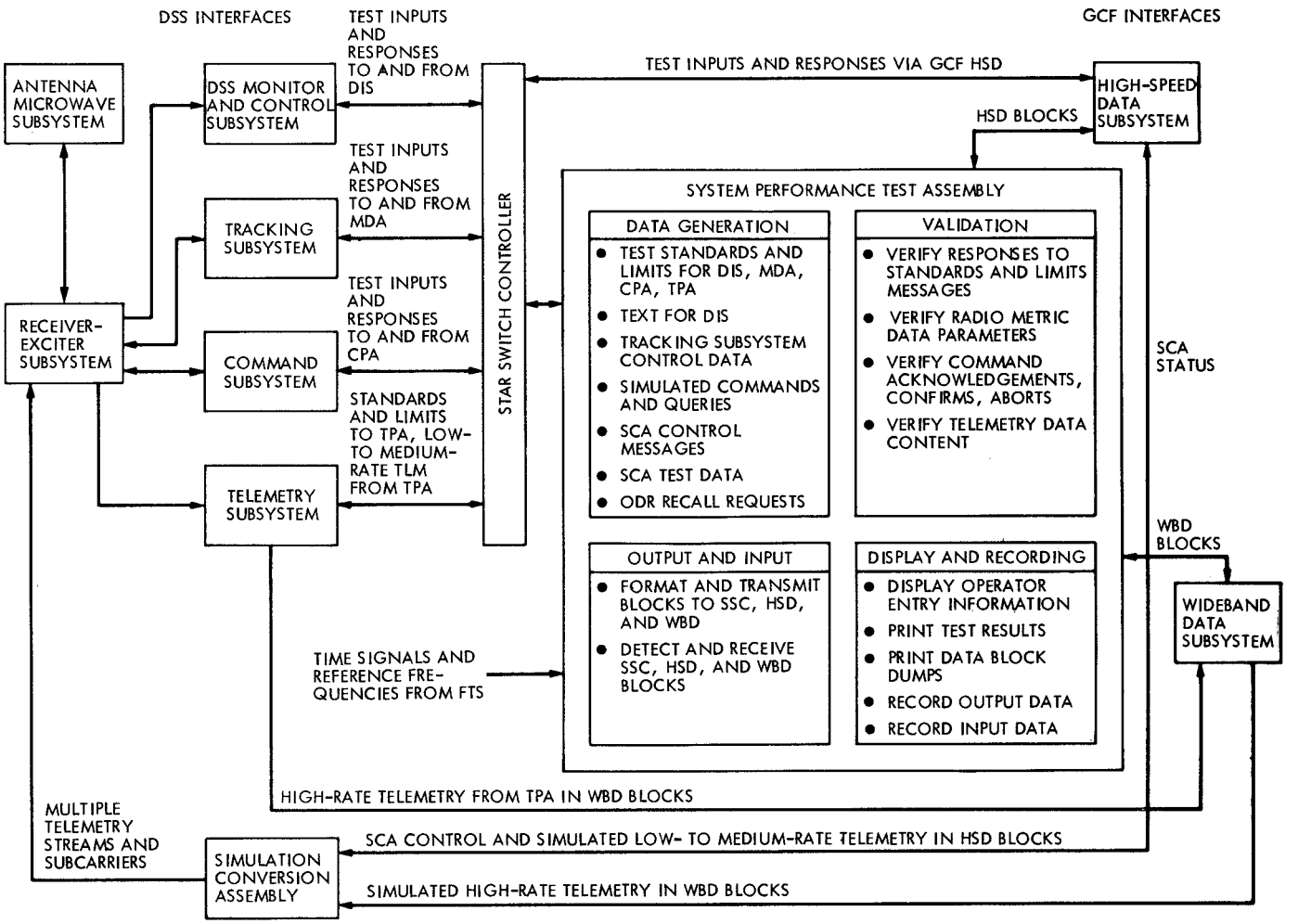

Fig. 4. System performance test assembly functions and data flow

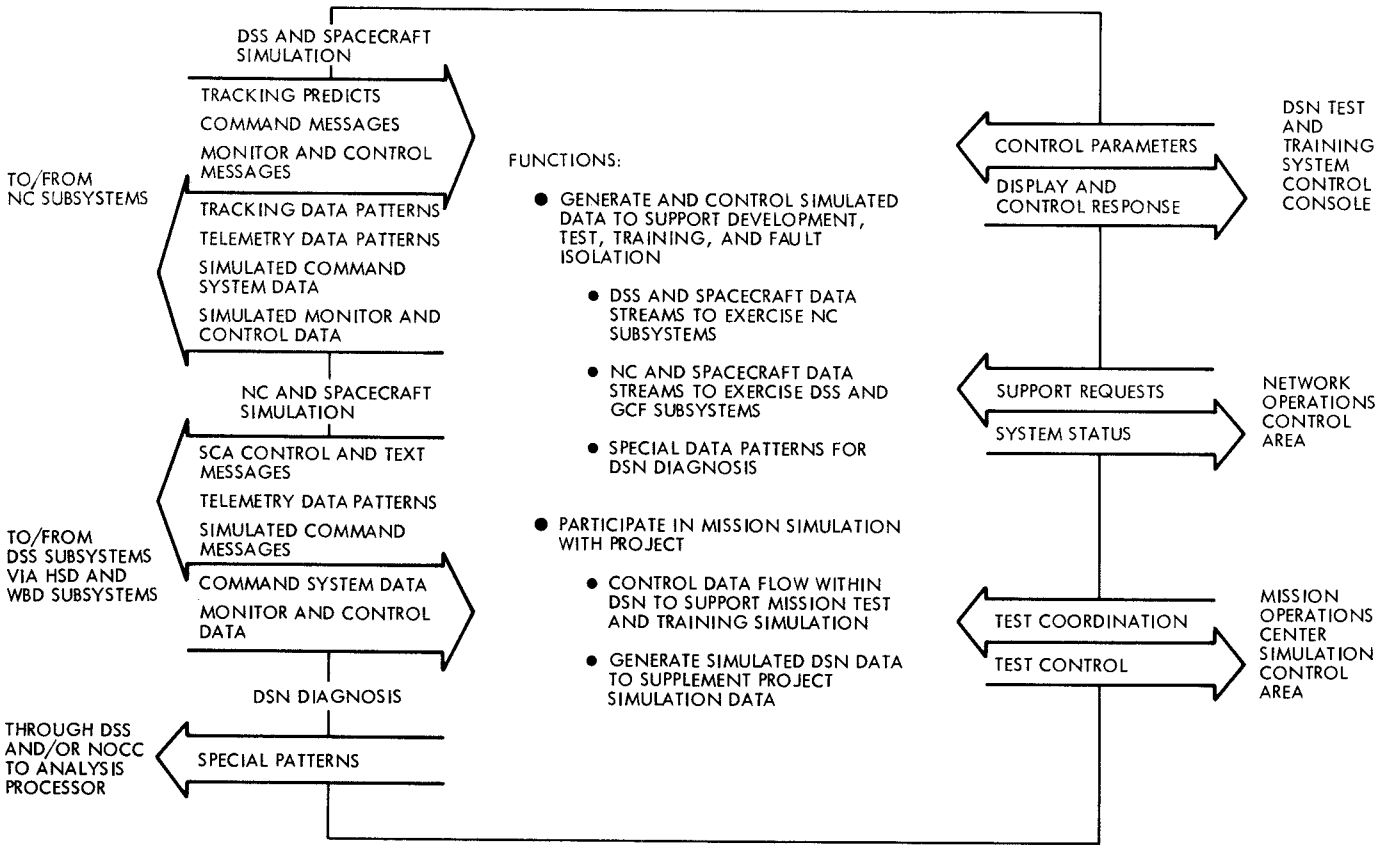

Fig. 5. NC Test and Training Subsystem functions and interfaces

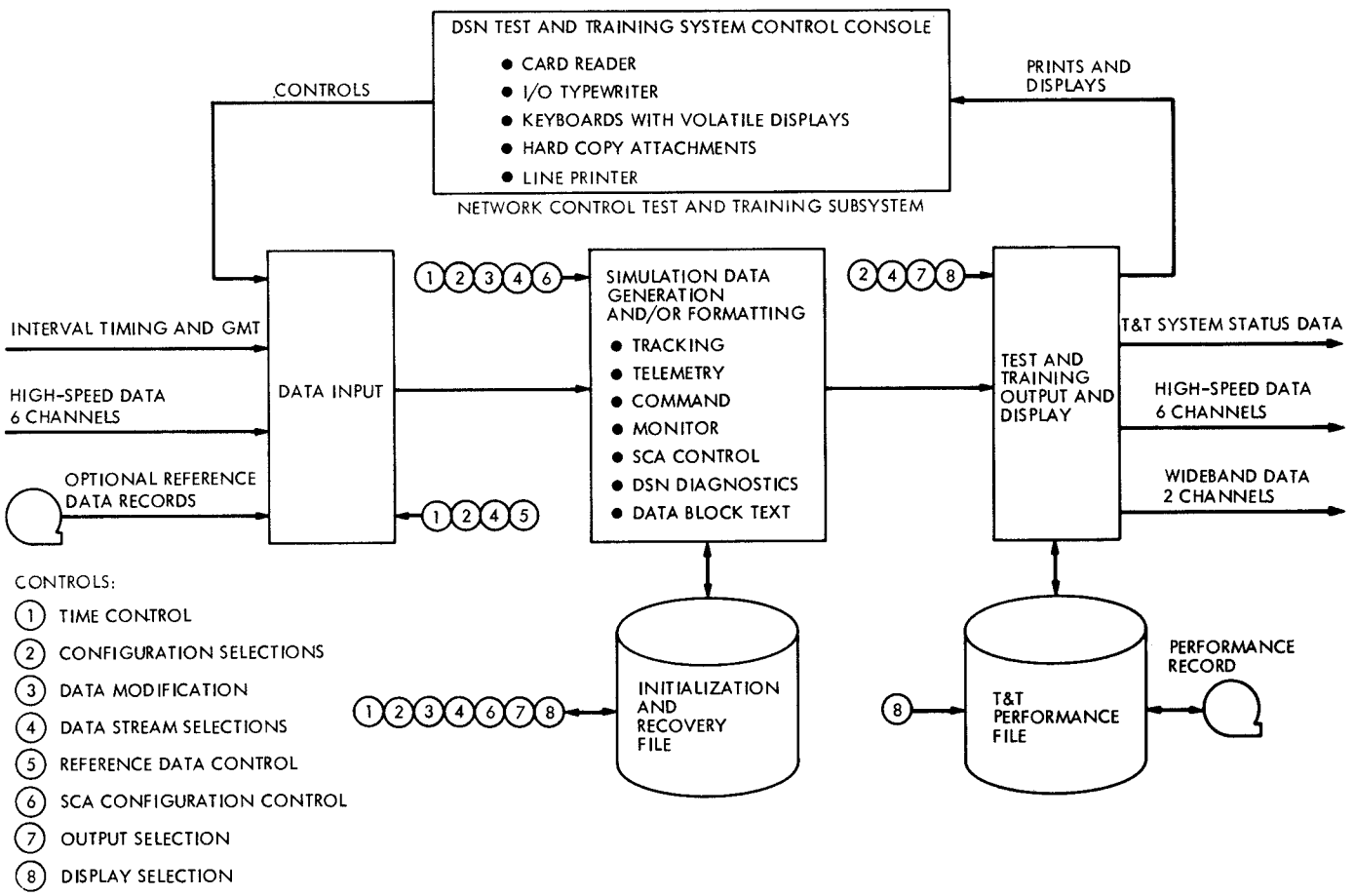

Fig. 6. NC Test and Training Subsystem data flow